Examples of stories of forces of nature

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OUTLINE:

- Introduction
- The Perpetuum Mobile story – an introduction to energy
- A story of cold – a figurative rendering of cold
- The Apple Story

If we want to use stories to teach physics, we are aware ours is **a** story of physics.
There are **stories of physics**, not a **unique** way to teach physics narratively.
On the contrary, when you read a textbook, you (feel to) find **the physics**.
There are different stories for physics, but there is a unique formal physics.
Are these two different levels of knowledge, lower the former, higher the latter, or are we in front of a contradiction?

Modern cognitive science tells us our mind is figurative. We do not know, understand, interpret, describe what actually nature is, but what images our mind creates to grasp the natural world.
Our understanding is not literal, objective, but metaphorical, figurative, imaginative.
Formal physics too!
Even formal physics is not the only physics, contrary to how it is presented, communicated, handed down to us.
So, a narrative approach to physics has nothing to envy to formal physics. The only difference is formalization, a matter of language, representation.
So, let's see some stories of forces of nature, that drive us to the knowledge of nature.

The Perpetuum Mobile story

–

an introduction to energy

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Let me anticipate some fundamental considerations conveyed by the story, then we will see and analyse how the story renders them figuratively.

- What is energy and what is not.
- What are forces of nature.
- What causes phenomena.

What is energy and what is not

The world is NOT divided into matter and energy.
Light, heat, electricity, motion… are NOT energy. It is best to understand these terms as denoting phenomena which have three basic characteristics (tension, [fluid] amount, and power or energy). We will call them: forces of nature.
Energy is an aspect of forces of nature, a property. It does not exist by itself.
What leads our mind think energy to “exist” is that it is common to every force of nature. But it remains an aspect of forces of nature, it has a different role than forces of nature.
In order to understand the role of energy in natural and technical systems and processes, we need to agree on the following distinction: forces of nature determine WHAT can happen, energy can only tell us HOW MUCH of this can happen. Energy is more like the bookkeeper in a company, NOT the CEO!

What are Forces of Nature

Let's go back in time when humans could literally "see" the natural agents and named them.
The Egyptians, for example, had Shu (wind), Geo (earth) , Nut (sky)…
Forces of nature are wind, water, rain, fire and ice, light, moisture, substances, food, lightening...

Humans knew (and we know) these natural agents and could (can) talk about them and describe them.

- Forces of nature are characterized by a size and an intensity. They can be more or less big, large, much; they can be at high or low intensity.
- Forces of nature are more or less powerful. Their power is a measure of how much strong consequences on other forces of nature or things they can cause.

Size and intensity tell us how much they could accomplish.

Force	Intensity/Potential	Size/Amount
Water	Pressure	Amount of water
Light	Brightness	Amount of light
Heat	Temperature	Caloric/entropy (Amount of heat)
Water in soil or air	Humidity	Amount of water
Linear motion	Speed	Momentum (Quantity of motion)
Rotation	rpm-s (angular speed)	Spin (Quantity of rotational motion)
Food	Quality	Quantity of food
Rain	Intensity	Amount of rain
Wind	Speed	Amount of air
Dissolved substance	Concentration	Amount of substance
Electricity	Electric potential	Quantity of electricity (Electric charge)

Forces of Nature and their intensity and size aspects

In physics, Forces of Nature are grouped into a small number of categories, that had become the physics contents.

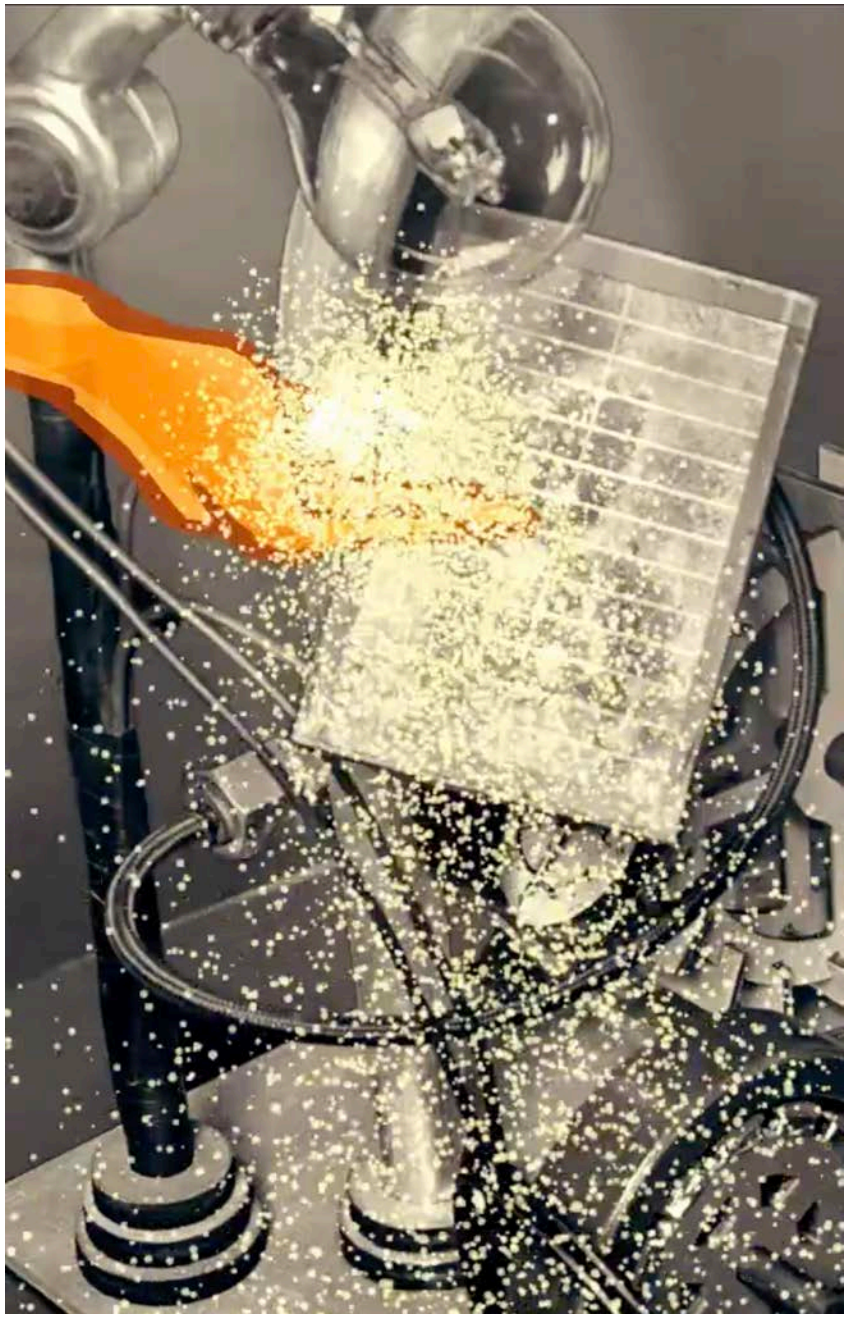
Phenomenon	Potential & Tension	Fluidlike Quantity	
Fluids	Pressure & pressure difference	Volume of fluid	ENERGY & POWER (†)
Electricity (*)	Electric potential & electric tension	Electric charge	
Heat	Temperature & temperature difference	Caloric (thermal charge, entropy)	
Substances	Chemical potential & chemical tension	Amount of substance	
Linear Motion	Speed & speed difference	Quantity of motion (momentum)	
Rotation	Angular speed & difference of angular speed	Spin (angular momentum)	
Gravity	Gravitational potential & difference of gravitational potential	Mass (gravitational mass or gravitational charge)	

What causes phenomena

Size and intensity tell us how much a force of nature can accomplish. Or rather, given its size/amount, it is its ***change in intensity*** that tells us how much it could accomplish.
Water could drive a water wheel if it flowed, and if it flowed from a high place to a lower place to do its work—it could drive the water wheel of a mill. There needed to be a ***difference*** of heights, a ***tension***, for the water to flow and to do its work.
It needed to be tense at first and then relaxed; and this is how it could be powerful.

Nothing could happen if there were no tensions. When the world was created, a first tension was set up: the sky separated from the earth because the wind went between them. Ever since then, the wind, Shu, has held the sky, Nut, above the earth, Geo, ensuring the existence of this first tension. And as long as it exists, life will continue.

VIDEO PERPETUUM MOBILE



Let us make this clear from the outset: the dust in the animation represents ***energy*** in physical processes.

There is a ***machine*** operating in some way. Apart from motion of some parts, it stays the same all the time; it is the material substrate of the story that is to follow.

The operations, the processes, appear to be governed by little ***ghosts.***
In the movie, there are agents for electricity, light, motion, water, and heat.
The agents drive the processes, or they are driven so they can then drive another process in turn. Clearly, they control the processes.

ELECTRICITY

relaxed

Agents appear to be either ***relaxed*** or ***tense***. When they are relaxed, they lie somewhere ***low***; when they tense up, they ***move up*** and are ready to ***meet another agent***.

tense

LIGHT

relaxed

Agents appear to be either ***relaxed*** or ***tense***. When they are relaxed, they lie somewhere ***low***; when they tense up, they ***move up*** and are ready to ***meet another agent***.

tense

relaxed

WATER

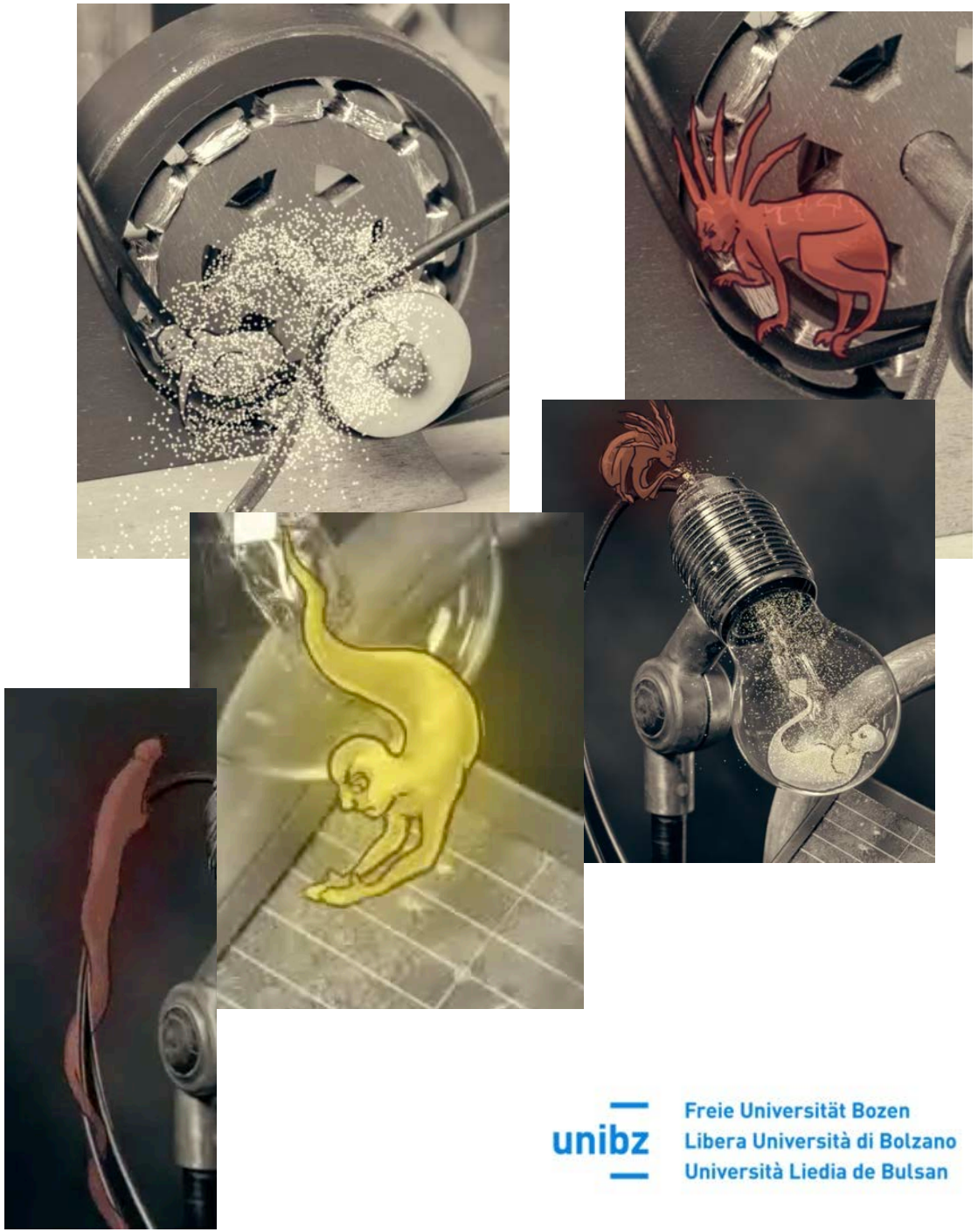
Agents appear to be either ***relaxed*** or ***tense***. When they are relaxed, they lie somewhere ***low***; when they tense up, they ***move up*** and are ready to ***meet another agent***.

tense

The agents meet in specific places where they are allowed to interact.

The heart of the energy exchange.

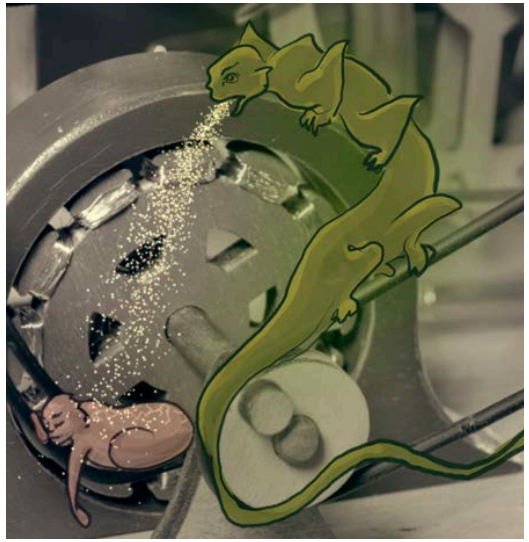
Right at the beginning we see what the dust that was ***made available*** to the machine by the inventor does: it wakes the first of the agents, the little reddish electricity spirit.
The electricity agent ***tenses up*** and moves up the wires to the lamp—it has become ***powerful***.
In the lamp, it ***hands off*** the dust it carried with it up the wire to the next agent—a light agent in the lamp, which now ***gets tense and drives the next electricity agent*** in the solar cell.
The first electricity agent ***makes the dust available*** to the light agent so this one can, in turn, do its job. Note that the ***electricity agent relaxed*** when it handed the dust over to the light spirit.



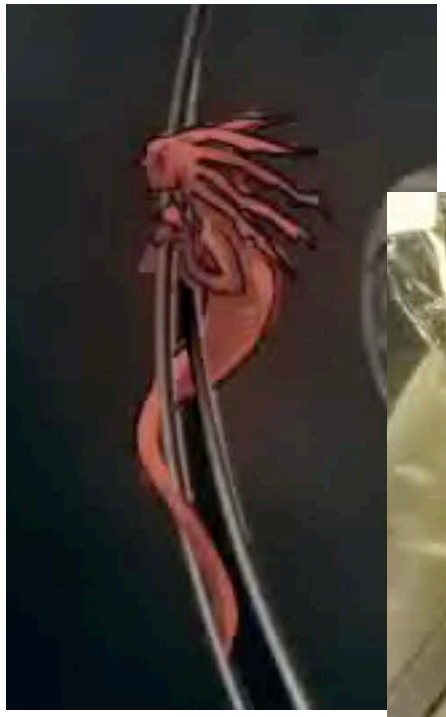
This process is repeated for every couple of agents.

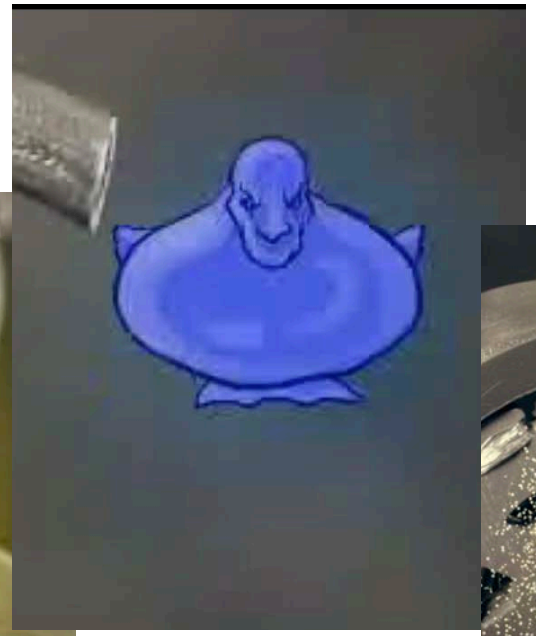
In general, there is an agent who is tense and powerful because it has received and now possesses some dust. It is now ready to “force” the next agent into action. It does so by handing over the dust, thus making the second agent (also called the patient) powerful.

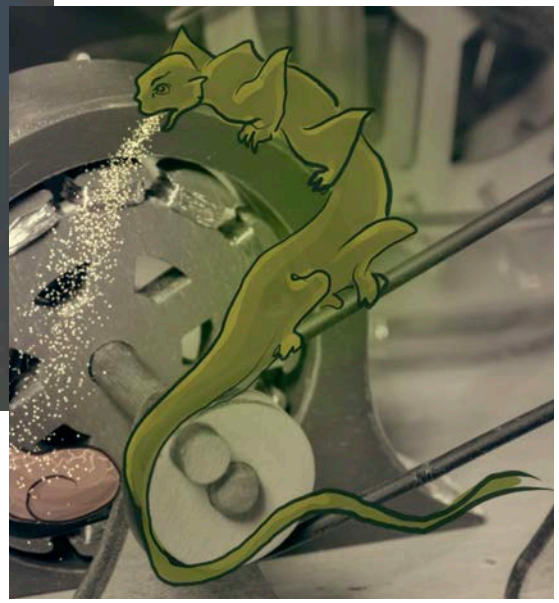
How much dust can be handed over, and how fast, somehow measures the ***power of an agent***.

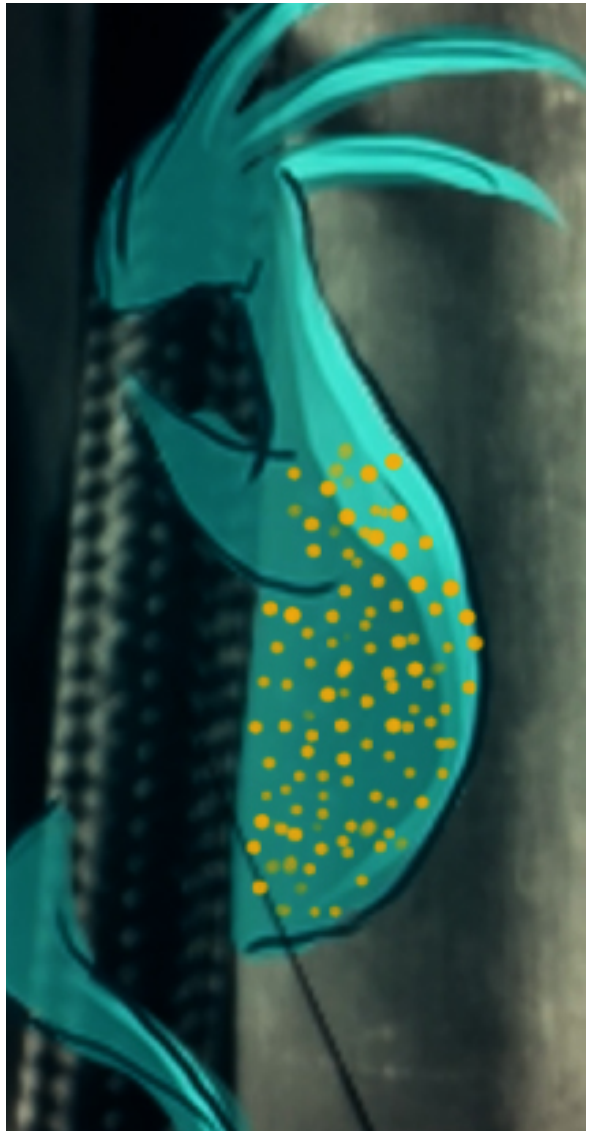


What happens between the times when the agents meet?
We should assume that an agent, that received dust from a first agent as a result of the interaction between the two, ***takes the dust with him on his way to the next agent.***
It would not make all that much sense to assume that the dust appeared and then disappeared again in the act of interaction of two agents.
Energy is **carried** around by the agents.

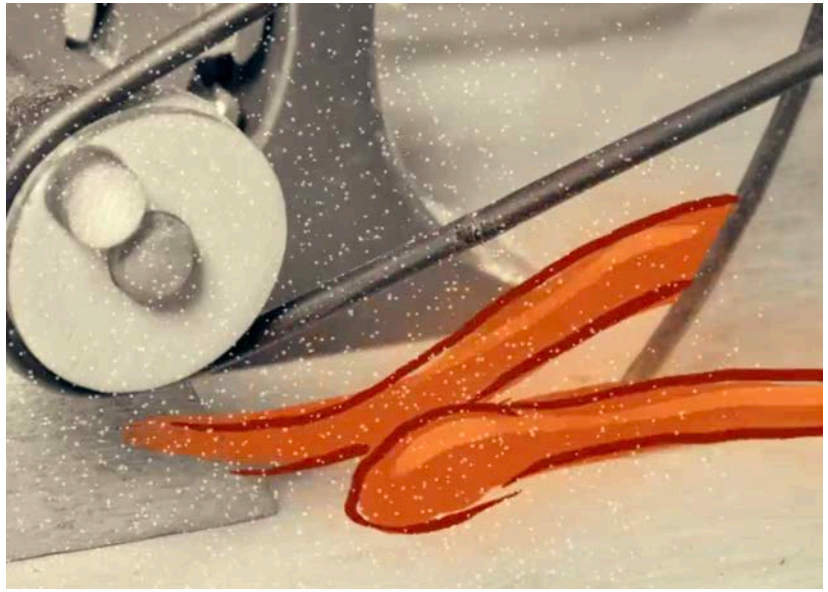


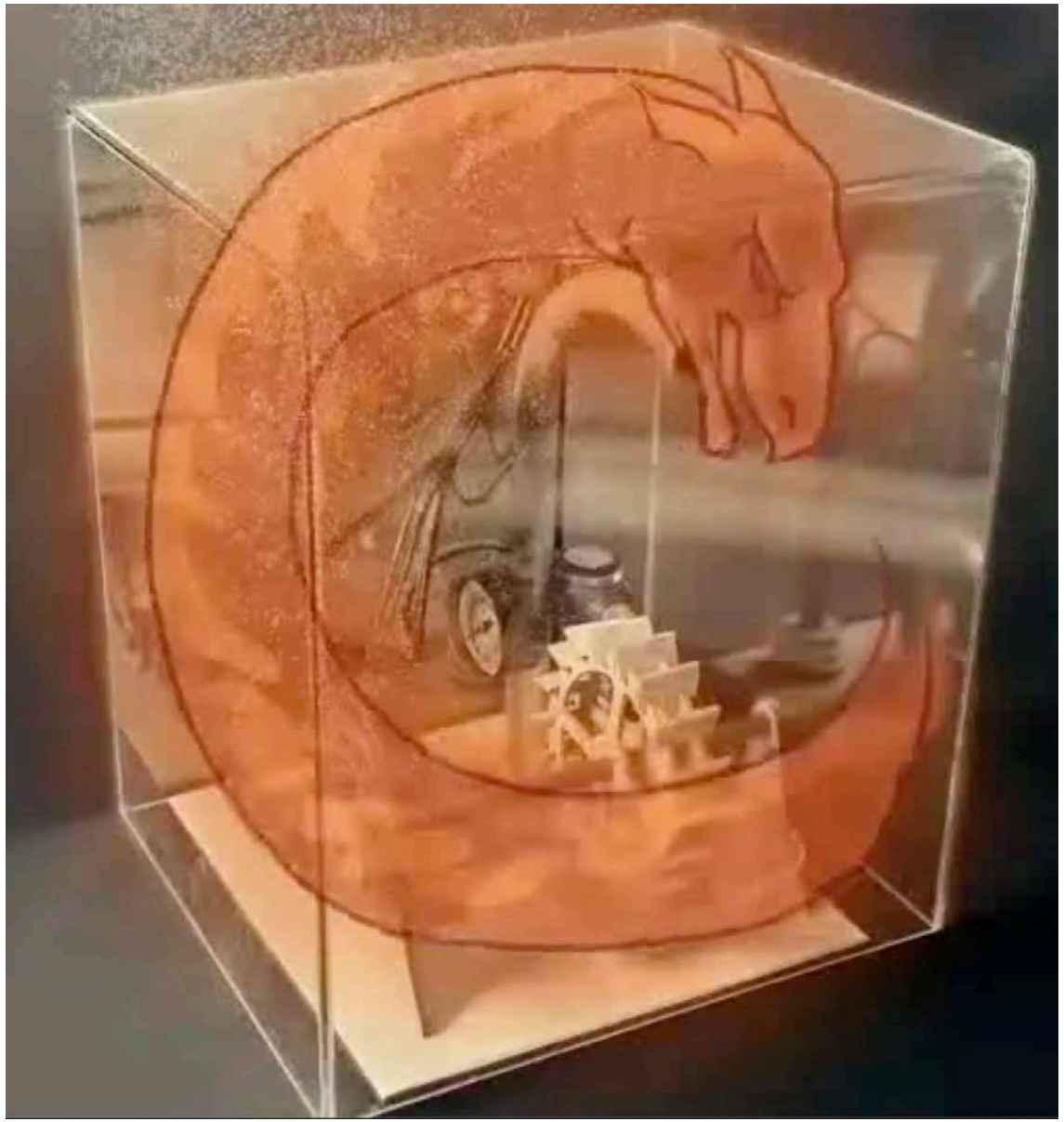






We have overlooked something quite obvious: the meeting between two agents, their interaction, is never a perfect affair.
Some of the dust always falls by the wayside—technically speaking, we say that the agent that is driven is able to obtain only a fraction of the energy made available by the driving agent.
The dust that falls to the ground—the energy, which we often call “lost”—is available for another thing to happen: heat is created.
There is a new ghost or agent leaving its mark upon our story—we can call it the ***heat agent***.





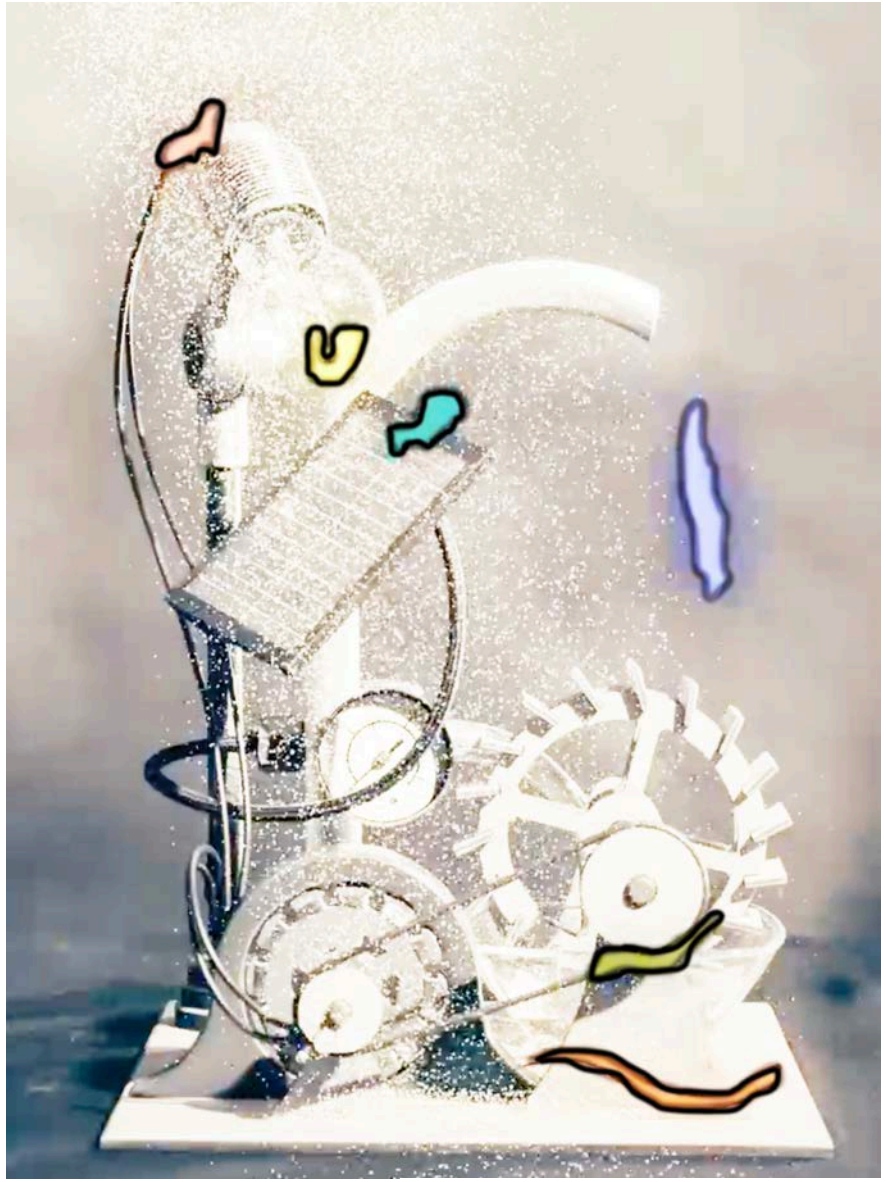
As energy increases in the glass case, the produced heat ghost becomes bigger and bigger. Together with heat, or in general, with agents, energy is **stored**.

Energy cannot be stored by itself. It will be contained in objects together with a force of nature.

There is one more important aspect of dust suggested by the video, even if not explicitly.

All that happens are these three things: dust ***can be made available or be used***, it can be ***transported***, and it can be ***stored***. When it falls to the ground, ***heat*** uses it.

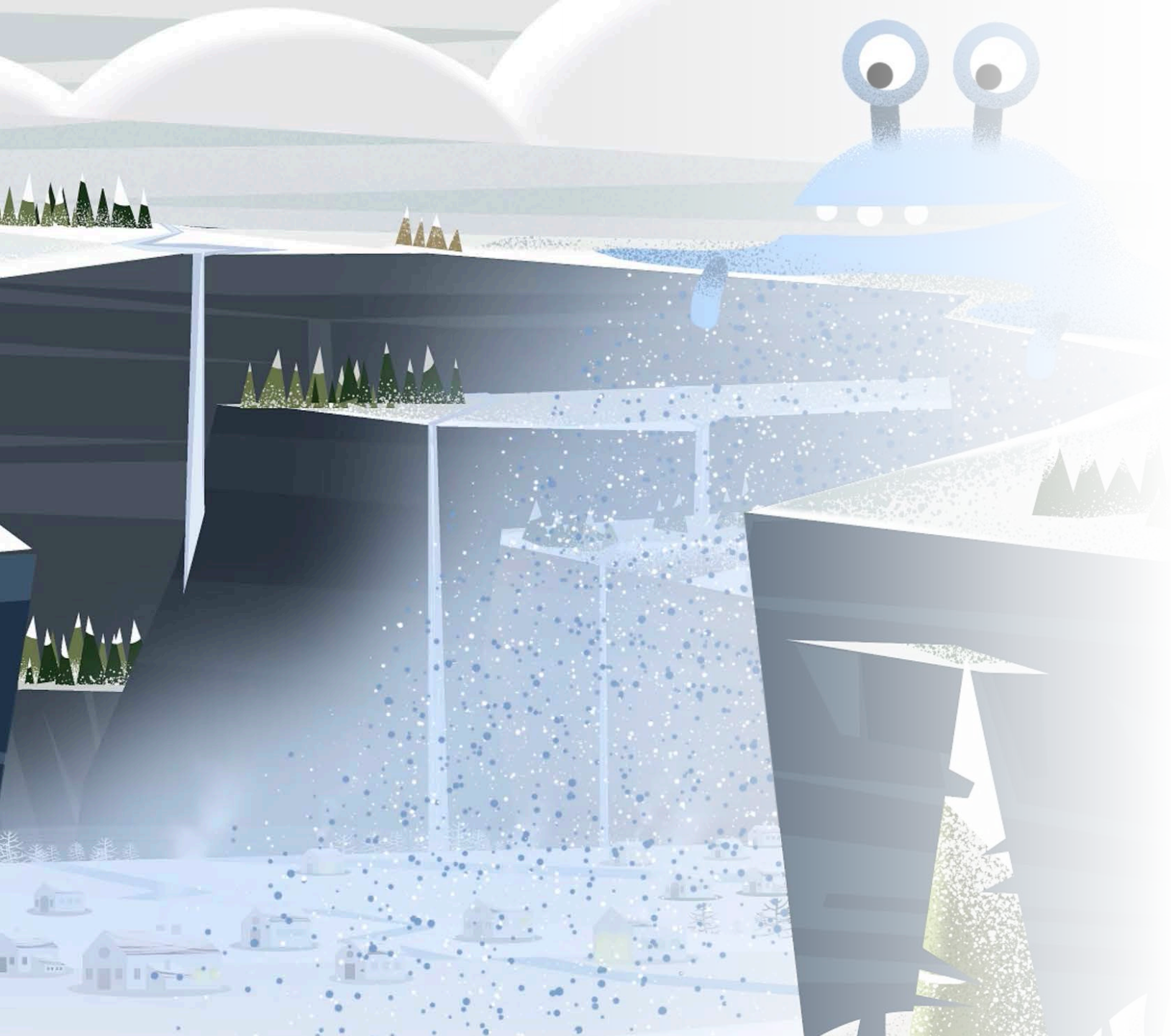
In other words, ***its amount dose not change.***
The amount of energy stays constant in the world.
It is not produced or destroyed.



Summary of the aspects of energy conveyed by the story and how it relates to forces of nature:

1. In interactions of forces of nature, ***energy is made available*** by the first (causing, driving) agent ***and used*** by the second agent (by the patient). An agent can make energy available only if it is tense. Energy is used by a patient, not used up.
2. Energy can be ***transported***. Agents carry the energy they have collected from one place of interaction (a device) to the next. We call the agents ***energy carriers***.
3. Energy ***is the same*** in all processes, there are no different types of energy. Energy is never converted.
4. A patient usually "misses" some of the energy made available by the agent. Energy that is "missed" by a patient in an interaction is not "lost." It is used by a new patient, namely, ***heat***.
5. Energy is ***not produced nor destroyed*** (or lost). There is always the same amount of energy in nature. (Physicists say, energy is conserved.)
6. Even though there is always the same amount of energy, energy can be used only if it has been made available by an agent. An agent can make energy available only if it is ***tense***.
7. Energy can be ***stored*** in materials (together with agents/patients that carry the energy).

VIDEO PERPETUUM MOBILE



A story of cold

–

a figurative rendering of cold

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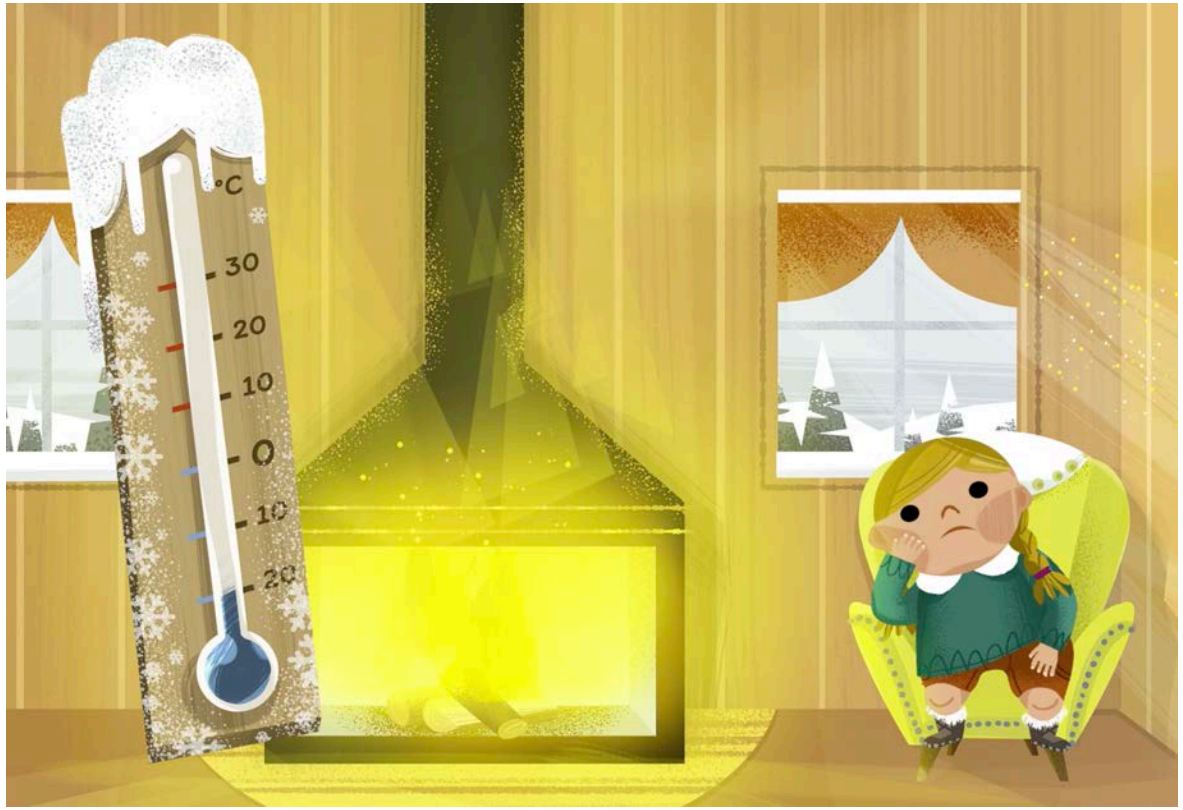
Aspects of Forces of Nature: Quantity/size, Tension, and Power

We experience nature as AGENTIVE and we imagine "AGENTS" responsible for the observed dynamics. The agents somehow embody what we experience.
An agent takes on the main characteristics of a force of nature:

- The agent has a certain SIZE—this represents the QUANTITATIVE (EXTENSIVE) aspect of a phenomenon (conceptualized with the **FLUID-LIKE SUBSTANCE** metaphor)
- The agent expresses a certain level of TENSION—this represents the INTENSIVE aspect of a force (conceptualized with the **SCALE, VERTICALITY** metaphors)
- The power of a force of nature is recognized WHEN TWO FORCES INTERACT. The causing force (agent) is called the AGENT; the caused force (agent) is called the PATIENT (conceptualized with the **DIRECT MANIPULATION** metaphors).

Aspects of Forces of Nature: Quantity/size, Tension, and Power



Note that three elements of our NATURAL LANGUAGES are used to speak about these aspects:

- ADJECTIVES: We speak of levels and tensions as "high" or "low."
- NOUNS (actually, MASS NOUNS): We speak of (quantities of) fluid, heat, motion, substance, humidity, light, electricity, and so on.
- VERBS: Power as a measure of how strongly an agent influences another, introduces causal verbs ("heat drives the motion of an engine," "sunlight combines with water and air to produce sugar in photosynthesis…").

Heat as Forces of Nature—A powerful agent appearing in our words

Level/Tension

…experiences indicate that **many levels** of **hotness** exist…

Temperature is a property which measures the **degree of hotness** or coldness of body.

The **thermal tension** of a thermogenerator depends on the temperature difference across the element.

There needs to be **tension between hot and cold**, so that pinot noir can ripen slowly and show a true and exciting expression of the site.

… seem to intuitively think of heat as a liquid and the **temperature as level of the liquid**.

Fluid-like quantity

…the object serving merely as a **container for heat**.

Thicker bodies **store much heat** and take longer to cool down.

While the fruit is swelling and ripening, the plants will want **abundance of heat** and air.

Geothermal add-ons for **heat pumps** on the market today **collect heat** from the air or the ground.

Like water, **heat flows** downhill. The greater the difference in temperature between two objects, the steeper the hill, and the faster the **heat will flow**…

Agent/Power

…just try frying an egg to observe the **transforming power of heat** on proteins…

The **force of heat** within our planet…

As we have shown, their experimental program centered on the **force of heat**.

Heat: An **Agent** of Change.

Although it is known that **heat is an agent** which causes damage to DNA …

Fire can be a clever **opponent**.

… her research provided insight into how **heat behaves as** it is conducted through rock.

Heat AND Cold—Or ONLY Heat?

There is an important difference between a direct experiential and imaginative approach to phenomena as Forces of Nature and a scientific treatment of phenomena:

- Our experience of the polarity of hot and cold, i.e., of hotness and coldness, leads us to imagine HOT AND COLD AS SEPARATE AGENTS. The perception of hot and cold is relative to our bodies: hot is what is warmer than we are, cold is what is colder than we. “Intuitive physics” allows us to work with hot and cold as separate but related forces.
- It turns out that we need to work with only one of the two pairs of qualities and quantities—either hotness/heat or coldness/cold—if we want to create a formal science of thermal phenomena.
  In physics, we choose HOTNESS/HEAT as the conceptual pair to work with.

VIDEO WINTER STORY

METAPHORS	LINGUISTIC METAPHORIC EXPRESSIONS
COLD IS A (FLUID) SUBSTANCE	*The cold found its way into the area and spread out.* *Because the plain was so wide, the cold of winter had to spread pretty thinly,…* *It could flow into the hollow… it could collect there…* *The cold could even sneak in through tiny cracks between walls and windows…*
THE DEGREE OF COLD IS A (VERTICAL) SCALE	*Winters in Little Hollow were harsh.* *So it was not all that cold up there.* *And it got colder and colder as the winter grew stronger. The temperature fell and fell.* *When it had become terribly cold and the temperature was very, very low…*
COLD IS A POWERFUL AGENT	*The cold of winter knew a good place where it could do its job of making everything and everybody cold…* *It went into the snow lying on the ground to make it very cold as well and this made the snow drier and harder to work with.* *It knew it would not be driven out so easily by a little bit of wind…* *The fires in the furnaces had to work very hard to fight the cold.*

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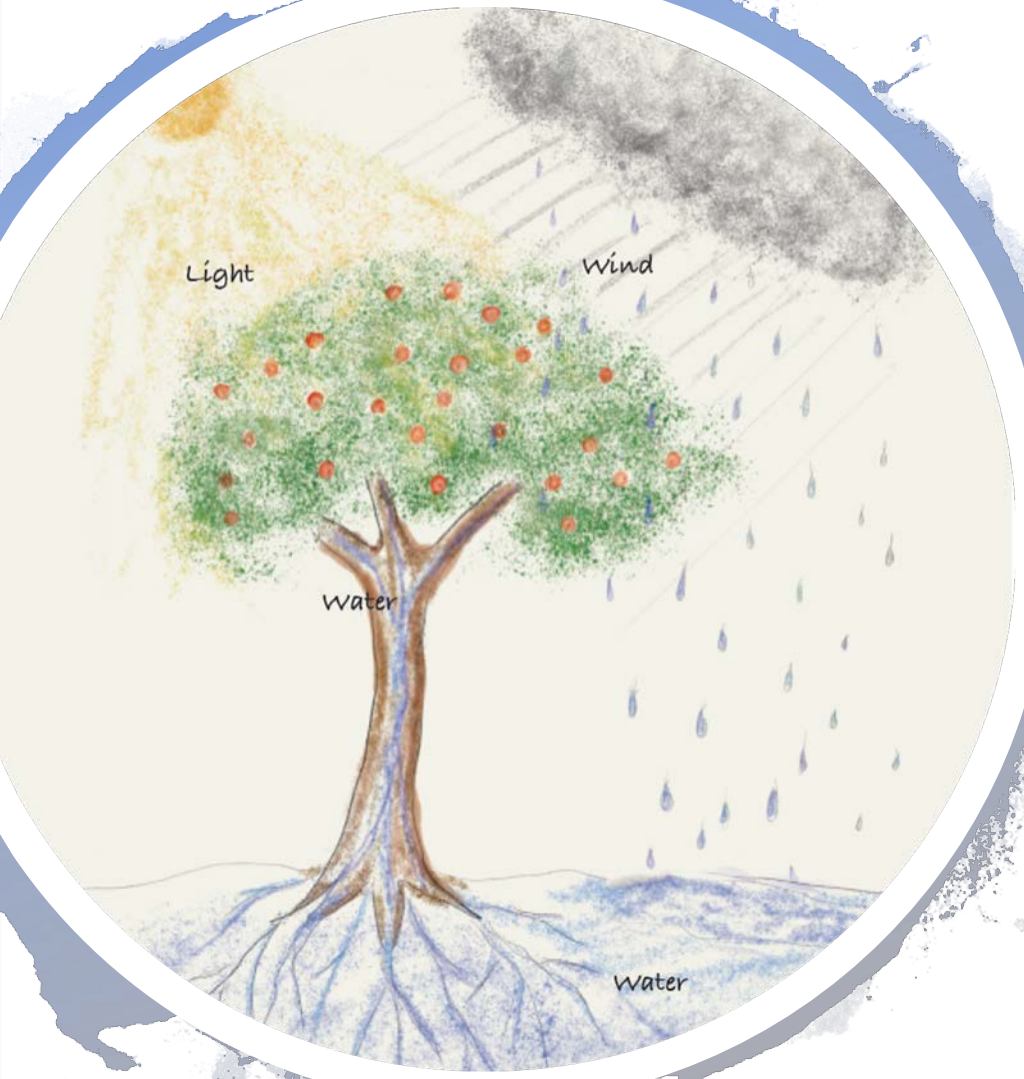

The Apple Story
–
an FCHgo material to introduce energy to young pupils

https://fchgo.eu/toolkit-development/

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The power of forces of nature—How narrative introduces us to the notion of energy

Hans U. Fuchs, Elisabeth Dumont, Federico Corni

Reggio Emilia, February 2019

Fuchs, H. U., Dumont, E., & Corni, F. (in press).
The power of forces of nature—How narrative introduces us to the notion of energy.
In F. Corni, & T. Altiero (Eds.), *Innovazione della didattica delle scienze nella scuola primaria e dell'infanzia: al crocevia fra discipline scientifiche e umanistiche*.

Force Dynamic Gestalt, Metaphor, and Scientific Thought

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Fuchs, H. U. (2011).
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Artestampa, Modena

Thank you for your attention!

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